Dynamic Cropping Systems and the Distribution of Research Information: Crop Sequence Calculator

J.M. Krupinsky, D.L. Tanaka, J.D. Hanson, S.D. Merrill, M.A. Liebig, and J.R. Hendrickson

Northern Great Plains Research Laboratory, Agricultural Research Service, USDA, Mandan, North Dakota. Corresponding author, J.M. Krupinsky (701-667-3011; krupinsj@mandan.ars.usda.gov).

Abstract
With dynamic cropping systems producers make critical management decisions in order to remain sustainable in an ever-changing agricultural environment. One of the key factors associated with dynamic cropping systems is information awareness, particularly on the influence of a previous crop and crop residues on crop production factors. A crop sequence research project used a crop matrix as a research tool to allow the evaluation of multiple crop sequences of regionally adaptable crops in the same experiment under the same weather and soil conditions. A user-friendly computer program entitled "Crop Sequence Calculator" (CSC) was designed by research scientists to help producers assess crop sequence information and calculate the expected crop production of ten crops (barley [Hordeum vulgare], canola [Brassica napus], crambe [Crambe abyssinica], dry bean [Phaseolus vulgaris], dry pea [Pisum sativum], flax [Linum usitatissimum], safflower [Carthamus tinctorius], soybean [Glycine max], sunflower [Helianthus annuus], and hard red spring wheat [Triticum aestivum] grown in any two-year combination. The CSC also contains information on economics, plant diseases, insects, weeds, crop water use, and surface soil properties to aid producers in their evaluation of management risks associated with different crop sequences. Even though the CSC information is only applicable to the Northern Great Plains, where annual precipitation averages less than 17 inches (43 cm), the concept of distributing timely research information to producers on a CD-ROM has been successful. The future challenge to research scientists is to provide such user-friendly information in an even more timely manner.

Introduction
A dynamic cropping systems approach has been proposed to help producers make critical management decisions in order to remain sustainable in an ever-changing agricultural environment. This system is defined as a long-term strategy of annual crop sequencing that optimizes crop and soil use options and attains production, economic, and resource conservation goals by using sound ecological management principles. Key factors associated with dynamic cropping systems are diversity, adaptability, reduced input cost, multiple enterprise systems, environmental awareness and information awareness. The timely flow of information among researchers, extension personnel, and producers is an important component of dynamic cropping systems (Tanaka et al. 2002).

With the adoption of conservation or reduced tillage cropping systems in the semi-arid environment of the Northern Great Plains region, annual cropping -- which includes alternative crops such as oilseeds, pulses, and forages -- becomes a viable option for producers (Greb, 1983; Peterson et al., 1996; Tanaka and Anderson, 1997). Proper sequencing of crops has long been viewed as crucial for cropping system success (Leighty, 1938; Pierce and Rice, 1988). For example, crop sequence may influence disease risk because of a crop's place in a rotation sequence (Krupinsky et al., 2002a). Thus, when incorporating new diverse crops into cropping systems, information on how to sequence crops is required.

Beginning in 1998, a multi-disciplinary team of scientists started a crop sequence research project with early- and late-season grass and broad leaf crops to determine the benefits and/or disadvantages of a previous crop and crop residues. Challenged by users of the research technology to make research results available in a timely manner, researchers took the initiative to produce a user-friendly computer program to transfer research information. The objective of this paper is not to present research results from a crop sequence project but rather to present an innovative way to transfer research information and technology to producers in a timely manner so they can develop their own crop production systems.

Materials and Methods

Because only a limited number of crop sequences can be evaluated in a fixed-rotation cropping system study, an experimental crop matrix design was developed allowing the simultaneous evaluation of numerous combinations of regionally adaptable crops in the same experiment under the same weather and soil conditions. A crop by crop residue matrix was utilized so ten crops could be seeded into the crop residue of the same ten crops (Figure 1). During the first year, ten crops (barley [*Hordeum vulgare* L.], dry bean [*Phaseolus vulgaris* L.], canola [*Brassica napus* L.], crambe [*Crambe abyssinica* Hochst. ex R.E. Fr.], flax [*Linum usitatissimum* L.], dry pea [*Pisum sativum* L.], safflower [*Carthamus tinctorius* L.], soybean [*Glycine max* (L.) Merr.], sunflower [*Helianthus annuus L.*], and spring wheat [*Triticum aestivum* L.]) were no-till seeded in strips (9 m wide and 90 m long) into a uniform cereal residue. During the second year, the same crops were no-till seeded in perpendicular strips over the residue of the previous year's crops. The resulting 10 x 10 crop matrix had 100 treatment combinations (Figure 1). Each experimental unit is a 9 x 9m plot. Four replications of the crop by crop residue matrix were established in 1999 and 2000. A uniform spring wheat crop was grown over the crop by crop residue matrices in 2000 and 2001. Growing season precipitation (May through August) was 197% in 1999, 112% in 2000, and 145% in 2001 of the long-term average (10 in, 25 cm). The research project was conducted at the Area IV Soil Conservation Districts/Agricultural Research Service Cooperative Research Farm near the Northern Great Plains Research Laboratory, southwest of Mandan, North Dakota.

Research data was obtained from 100 crop matrix plots in 1999 and 2000, and from 100 spring wheat plots in 2000 and 2001. Data included crop yield and residue production, concentrations of nitrogen and phosphorus in seed and residue, root growth, soil-surface residue coverage, and effect of the ten crops on plant diseases and weed populations. Plant diseases included the foliar diseases of spring wheat and barley and sclerotinia disease (white mold; *Sclerotinia sclerotiorum* (Lib.) De Bary) on sunflower, canola, crambe, and safflower. In addition, a standard set of soil quality indicators were measured in treatments where the same crop was planted in consecutive years.

Results and Discussion

The volume of research data obtained from the crop sequence project and the need for a method to make this data available to users of the research data led to the development of the Crop Sequence Calculator (CSC), an interactive computer information product (Fehmi et al, 2001; Krupinsky et al., 2002b). The CSC was designed to help producers assess crop options and crop sequencing information in a timely manner. The CSC runs directly from a CD-ROM, eliminating the need for additional disk space or installation procedures. The CSC is designed for computers running Windows® (95/98/ME/NT/2000) and works best with a screen area of 800 X 600 pixels or greater. The CSC can show the short-term experimental crop production effects of the ten crops grown in any two-year combination. Expected crop prices and loan deficiency payments or crop premiums can be entered to provide rapid calculations. Past short-term experimental returns can be modified to provide estimated returns. Once the previous crop (residue producing crop) and the expected crop are entered with a click of the mouse, summary statements appear for crop production, economics, plant diseases, soil water, weeds, soil surface properties, and insects. This information aids producers in an evaluation of management risks associated with different crop sequences. The CSC also provides an introduction to the dynamic agricultural systems concept (Tanaka et al., 2002) and the crop sequence research project. Informative websites are also listed. Supplemental information, which is usually not readily available in a single resource, is easily accessed. For example, plant disease information includes an introduction to plant diseases, research data, internet resources, and photographs of plant diseases to aid in their identification. The CSC also includes numerous photographs of weeds and insects to aid in identification. Information is only applicable to the northern Great Plains where annual precipitation averages less than 43 cm (17 in).

The Crop Sequence Calculator can save producers money by optimizing net returns for a given crop rotation. For example, a producer who grows dry bean after barley can expect an average net loss of $3 per acre. However, if that same producer grew dry bean after wheat, the result would be a net gain of $64 per acre. The CSC shows net returns for dry bean varied by as much as $105 per acre depending on the previous crop. Wheat was much more stable and showed differences of less than $20 per acre depending on crop sequence. Considering the hundreds of farm acres planted to various crops each year, the CSC provides substantial savings to producers who take advantage of this important technology.

The CSC provides information awareness, one of the key factors of a dynamic cropping system. The number of requests for the CSC clearly indicates that this technology fulfills a substantial need of the agricultural community. Since its release in mid-January, 2001, over 2,300 copies of the CSC, v. 1, and over 6650 copies of CSC, v. 2 have been distributed, making a total distribution of nearly 9,000 copies (as of June, 2003). The impact of the CSC has been far reaching. In addition to being requested by hundreds of individual producers, the CSC has been promoted and requested by numerous groups within the agricultural community. For example, the CSC was featured in The Sunflower Magazine (Anon. 2001, 2002), a publication of the National Sunflower Association. The CSC was featured in the Agricultural Research magazine (Comis, 2002). Requests have been made to demonstrate the CSC at the board meetings of several commodity groups and at a number of producers meetings in the US and Canada. Seed companies have requested many copies of the CSC for their suppliers and customers. At the request of the USDA—Natural Resource Conservation Service, the CSC has been placed in all NRCS field offices in North Dakota. Internationally, the CSC has been requested by Canadian producers and agricultural scientists. A number of Canadian and U.S. banks have seen utility in the use of the CSC as a spring planning tool and have requested copies for their use and for use by their customers. Scientists of the North Dakota State University Extension Service also have distributed the CSC throughout North Dakota, South Dakota, and eastern Montana.

The concept of using CSC-type technology to distribute information has been successful. Even producers outside the northern Great Plains region have requested a CSC-like product for their particular regions. As producers become accustomed to new information technologies, they are not as willing to accept a time lag in receiving the latest in research information as they were in the past, particularly with a challenging economic environment. The future challenge to research scientists is to provide user-friendly information that can be readily accessed by producers in a more timely manner.

Acknowledgments

We thank D. Wetch, J. Hartel, C. Flakker, M. Hatzenbuhler, D. Schlenker, M.K. Tokach, C. Klein, J. Bullinger, and L. Renner for technical assistance.

References

Anonymous. 2001. Crop Sequence Calculator. The Sunflower 27:16.

Anonymous. 2002. Crop Sequence Calculator Updated., Version 2.0 now available. The Sunflower 28:18.

Comis, D. 2002. So the Rain Stays in the Plain, Crop Sequence CD Helps Farmers Fight Drought. Agricultural Research 50(7):7.

Fehmi, J.S., J.M. Krupinsky, D.L. Tanaka, S.D. Merrill, J.R. Hendrickson, R.E. Ries, M.A. Liebig, and J.D. Hanson. 2001. A Crop Sequence Calculator for Designing Dynamic Cropping Systems: Translating Science into Practice. No. 210215-P In: Annual Meeting Abstracts, October 21-25, 2001, Charlotte, NC, ASA-SSSA-CSSA, Madison, WI.

Greb. B. W. 1983. Water conservation: Central Great Plains. p. 57-72. In H. W. Dregne and W. O. Willis (ed.), Dryland Agriculture. Spec. Publ. No. 23. ASA, CSSA, and SSSA, Madison, WI.

Krupinsky, J.M., Bailey, K.L., McMullen, M.P., Gossen, B.D., and Turkington, T.K. 2002a. Managing plant disease risk in diversified cropping systems. Agron. J. 94:198-209.

Krupinsky, J.M., D.L. Tanaka, J.S. Fehmi, S.D. Merrill, M.A. Liebig, J.R. Hendrickson, J.D. Hanson, R.L. Anderson, D. Archer, J. Knodel, P.A. Glogoza, L. D. Charlet, S. Wright, and R.E. Ries. 2002b. Crop Sequence Calculator, v. 2, A revised computer program to assist producers. p. 63-66 *In* Proc. of the 24th Sunflower Research Workshop, National Sunflower Assoc, Bismarck, ND (order from the ARS website: www.mandan.ars.usda.gov)

Leighty, C.E. 1938. Crop Rotation. p. 406-430. *In* USDA Yearbook of Agric. Soils and Men. U.S. Gov. Printing Office, Washington, DC.

Peterson, G. A., A. J. Schlegel, D. L. Tanaka, and O. R. Jones. 1996. Precipitation use efficiency as affected by cropping and tillage system. J. Prod. Agric. 9:180-186.

Pierce, F.J., and C.W. Rice. 1988. Crop rotation and its impact on efficiency of water and nitrogen use. p. 21-42. *In* W.L. Hargove (ed.) Cropping Strategies for Efficient Use of Water and Nitrogen. ASA, CSSA, and SSSA. Madison, WI.

Tanaka, D.L., J.M. Krupinsky, M.A. Liebig, S.D. Merrill, R.E. Ries, J.R. Hendrickson, H.A. Johnson, and J.D. Hanson. 2002. Dynamic Cropping Systems: An adaptable approach to crop production in the Great Plains. Agron. J. 94:957-961.

Tanaka, D. L., and R. L. Anderson. 1997. Soil water storage and precipitation storage efficiency of conservation tillage systems. J. Soil Water Conserv. 52:363-367.

Copies of the Crop Sequence Calculator can be ordered from the ARS website: www.mandan.ars.usda.gov

Figure 1. A crop by crop residue matrix. During the first year ten crops (numbered 1 through 10) are seeded into a uniform cereal crop residue. During the second year the same crops are no-till seeded perpendicular over the residue of the previous year's crop. Observations made during the second year of the matrix are incorporated into the Crop Sequence Calculator. Individual plot numbers are assigned for each replication.

Crop by Crop Residue Matrix, 1 Replicate, 100 Plots										
1	2	3	4	5	6	7	8	9	10	1
11	12	13	14	15	16	17	18	19	20	2
21	22	23	24	25	26	27	28	29	30	5
31	32	33	34	35	36	37	38	39	40	9
41	42	43	44	45	46	47	48	49	50	7
51	52	53	54	55	56	57	58	59	60	10
61	62	63	64	65	66	67	68	69	70	6
71	72	73	74	75	76	77	78	79	80	3
81	82	83	84	85	86	87	88	89	90	4
91	92	93	94	95	96	97	98	99	100	8
5	2	7	1	8	4	6	9	3	10	

1st year, ten crops seeded in strips

2nd year, ten crops seeded perpendicular over crop residue